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PRINCETON UNIVERSITY

Department of Astrophysical Sciences

Final Report

for grant NSG-7256

"Research in Extragalactic Astrophysics"

for

National Aeronautics and Space Administration

Washington, D.C.

By: Neta Bahcall
Principal Investigator

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Several research projects leading to exciting new results on the spatial distribution of clusters of galaxies and the large scale structure of the universe have been accomplished under the support of this NASA grant. The studies reveal correlations in the spatial cluster distribution that are much stronger than seen for galaxies, and over scales much larger than previously anticipated. These results are of fundamental importance to theories of galaxy formation and clustering, and have generated much interest and further new work by various groups in this field. The following main studies have been completed and published.

1. The determination of the correlation functions of rich clusters of galaxies, and its dependence on richness and other parameters. The results yielded very strong correlations (20 times stronger than the galaxy correlation strength) that extended to separations of $\sim 100h^{-1}$ Mpc (as compared with $\sim 20h^{-1}$ Mpc for the galaxies). It is concluded therefore that very large scale structure exists in the universe, and that rich clusters participate in this structure more efficiently than galaxies. These results put constraints on some theoretical models for the formation and evolution of galaxies.

2. A complete catalog of superclusters, i.e., groups of rich clusters, to $z \leq 0.08$, has been determined. The selection criteria is that of a volume density enhancement, and is done in 3-dimensions. The properties of the cataloged superclusters are investigated as a function of density enhancement. This catalog will provide a useful complete list of superclusters for various optical, x-ray, radio and statistical studies of clustering phenomena.

3. The giant galaxy void in Bootes was found to be surrounded by rich, large superclusters from the catalog described above. The excess galaxies observed by Kirshner et.al. around the void appear, according to our study, to belong to the tails of these large scale ($\sim 100h^{-1}$ Mpc) superclusters. It is likely that all voids (or underdensities), small or large, are surrounded by appropriate superclusters. This fact, plus the shape of the voids and superclusters, will provide important clues to our understanding of the formation and evolution of structure in the universe.

4. A very large scale ($\sim 300h^{-1}$ Mpc) void of rich clusters of galaxies was found in our study of the spatial distribution of rich clusters. This finding is consistent with our other results that large scale structure is present on scales of order $100h^{-1}$ Mpc, and is traced well by the distribution of the rich clusters.

The results of the studies are described in more detail in the papers listed below (all appearing in the Ap.J. and Ap.J. Letters).

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